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WATER CONSUMPTION BEHAVIOR IN SEMI- RURAL AREAS IN THE GAZA STRIP: BEIT LAHYA TOWN AS ACASE STUDY

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ملخص: تعتبر المياه الجوفية المصدر الرئيسي لمياه الشرب في المناطق الحضرية والريفية في قطاع غزة. فالنمو السكاني والتوسع العمراني له أثر كبير في زيادة الطلب على المياه واستهلاكها في مجالات مختلفة، وتكمن أهمية هذا البحث في دراسة سلوك استهلاك المياه في المناطق الشبه حضرية وذلك بدراسة الوضع الحالي لشبكة مياه بيت لاهيا ودراسة الكميات التي يتم ضخها من الآبار للشبكة وأيضاً دراسة كميات المياه المفقودة ومدى تأثير الأراضي الزراعية على كفاءة شبكة المياه في البلدة. وبناء على ذلك قام الباحثون بمسح ميداني لمنطقة الدراسة لمعرفة نسبة الأراضي الزراعية ومصدر ري هذه الأراضي الزراعية وكميات الزراعة في كل حي من أحياء مدينة بيت لاهيا ، كما تم متابعة قراءات عدادات المشتركين (مياه وصرف صحي) لمدة ثلاث دورات متتالية دورة شهر مايو ويونيو 2011، دورة شهري يوليو وأغسطس 2011 ثم دورة فصل الشتاء في شهري يناير وفبراير 2012م .

وكان من أهم النتائج التي تم الحصول عليها في هذه الدراسة أن المزارعين في المدينة يستخدمون مياه شرب البلدية في ري مزروعاتهم الأمر الذي يؤدي إلي زيادة نسبة الفاقد في شبكة المياه والتي وصلت إلي ما يزيد على 60%، وبالتالي زيادة نسبة نصيب الفرد من كميات المياه حيث وصلت حسب الدراسة إلى 230 لتر/ فرد/ اليوم . وبلغت كفاءة شبكة المياه في الصيف 42% وارتفعت الكفاءة في فصل الشتاء إلي 55.7% ،وفي بعض المناطق الشبة ريفية مثل منطقة السلاطين وصلت كمية الفاقد في المياه إلي 73%، ولذلك ومن خلال دراسة الفروق في كميات المياه التي تضخ للشبكة وبين استهلاك المشتركين للمياه يؤكد استخدام المزارعين مياه الشرب لري مزروعاتهم بصورة غير قانونية.

لذلك وجب على البلدية اتخاذ سياسات وقوانين جديدة لتنظيم و إدارة موارد المياه في المناطق الشبه حضرية في قطاع غزة.

الكلمات المفتاحية: التزويد بالمياه، المياه المفقودة، وصلات مياه غير شرعية ، زراعة حضرية

Abstaract: Groundwater is the major source of drinking water in both urban and rural areas in the Gaza Strip. Population growth and urban expansion have persistently raised the demand for water supply and consequently, greatly increased the exploitation of groundwater in the Gaza

strip. The importance of this research is to investigate the water consumption behavior in semi-rural area by studying the current distribution situation, water demand and supply, the unaccounted for water and studying the effect of urban agriculture on the system efficiency. Therefore, field survey to determine the sources of water for irrigation, the agricultural area and water meter readings was conducted for continuous three periods two in summer and one in winter. Urban agriculture is one of the most persistent approaches for supplying food in the Gaza Strip. The main outcomes of the study are that; farmers use the domestic network illegally for irrigation purposes leading to high percentage of unaccounted for water. This leads to higher water consumption per capita in Beit Lahya which apparently exceeds 230 l/c/d according to water well production in year 2010 equal (6.098 MCM) and the unaccounted for water more than 60% in semi urban quarters where green houses are the main agricultural practice. The difference between supply and demand indicates that the farmers use illegal connections to irrigate the adjacent agricultural areas. The overall system efficiency for water distribution is 42.0% and 55.7% for summer and winter periods, respectively. The quarters with intensive agriculture show high percentage of unaccounted for water (73%), while the urban quarters unaccounted for water is 24%. Therefore new policy and regulations concerning water resources management should be implemented for the semi urban areas in the Gaza Strip.

Key words: Water supply, Unaccounted for water, illegal connections, urban agriculture

I. INTRODUCTION

Unaccounted-for water (UFW) represents the difference between "net production" and "consumption" (the volume of water that can be accounted for by legitimate consumption, whether metered or not) (Sharma, 2008). Water loss levels (UFW) vary widely per country and within one country per city and it ranges from 6% to 63%. Water loss (UFW) from a water distribution system is a significant factor affecting water delivery to customers. Water loss can be either: (a) the apparent losses due to meter inaccuracies or unauthorized consumption, or (b) real losses due to leakage at water service lines, breaks or leakage on mains and hydrants at storage facilities (EPD, 2007). Non-revenue water (NRW) represents the difference between the volumes of water delivered into a network and billed authorized consumption. AWWA Leak detection and Accountability Committee (1996) recommended 10% as a benchmark for UFW as the following: < 10% Acceptable, monitoring and control. 10-25%, intermediate, could be reduced and > 25% matter of concern, reduction needed (Sharma, 2008). In many areas in the Gaza Strip un-account for water exceeds 50% especially in the Semi-rural areas such as Beit lahya and Rafah. It is found on the semi-rural areas that the unaccounted for water is very high

compared with the urban areas. This phenomenon ensures the fact of using municipal water supply for irrigation purposes in the semi-rural areas. Therefore the main objective of this research is to identify the high losses in the distribution system and the effect of urban agriculture in Beit Lahya town on the behavior of water consumption in order to improve the water services offered by the municipality and to minimize the overwhelming pressure on the groundwater.

II. STUDY AREA

Beit Lahya is located at the northern part of Gaza Strip. The population of Beit Lahya city reached 64,457 inhabitants in 2007 (PCBS, 2009), so the population in 2012 is 78422 inhabitants considering the growth rate of 4%. Beit Lahya municipality consists of the following zones: Salatin area in the south-west, Atatra area in the West directly, Aslan in the middle, West region, Sheikh Zayed City, East Region, Fardous Region, Masroa Region, Om AL-Faham, AL-Fardous. Herbia Village bordered Beit Lahya in north, the Mediterranean Sea on the west and Beit Hanoun on the east. The sand dunes rounded the city, the agriculture land area within Beit Lahya city is about 25.53%. Most of the agricultural lands are concentrated in Beit Lahya town. Water supply in Beit Lahya municipality is an intermittent water supply due to insufficient water quantity in the area. The operation system is controlled manually by opening/closing valves on the major trunk lines. The water distribution cycle is completed every 24 hours.

III. METHODOLOGY

The necessary information required by the research have been collected from the relevant institutions such as, Palestinian water authority (PWA), municipalities, the Ministry of Local Government (MoLG), the Ministry of Agriculture (MoA), Coastal municipal water utility (CMWU) and local NGOs. The lack of data regarding water use for agriculture is one of the main characteristics of Beit Lahya municipality. All water wells, water distribution districts and the network layout were redrawn on the structural map of Beit Lahya by using the GIS techniques. This map was not available to the municipality with its final constitutions.

During the research period, which extends from 1/5/2011 until 28/2/2012, meters of all water consumers have been read, whose number is 5400 consumers in the entire area of Beit Lahya. Readings of water meters have been conducted through volunteers. It is noteworthy that water bill is issued by Municipality of Beit Lahya periodically every two months. Therefore, one cycle have been conducted, which took place in 30/09/2011 for the period of July and August. Meters readings before the study were conducted randomly

and inaccurately because the number of the readers was not enough considering the number of the customers (staff of three members to read 5400 water meters). An agriculture land of each of water distribution area has been determined, and projected on the structural map of Beit Lahya by using GIS technique.

IV. RESULT AND DISCUSSION

IV.I. Water network operation zones

Water supply in Beit Lahya Municipality is an intermittent water supply due to insufficient water quantity in the area. The operation system is controlled manually by opening/closing valves on the major trunk lines. The water distribution cycle is completed every 24 hours. Water network in Beit Lahya city is composed of 13 operation zones varying in size, complexity, topography, and source management Figure 1. These zones are allocated based on the current supply sources. This includes identifying the supply sources of each zone and main operating valves related to these zones.

IV.II. Time schedule of Water Distribution System in Beit Lahya Municipality

Tables 1 and 2 show the feeding wells of each water distribution district together with the pumping hours and rate for the summer months (June, July and august) and winter months (December, June, July) for 2011 cycle, respectively, as reported by water department in the municipality. Many areas get water from more than a well such as Manshaea district, which is fed by Gaben and Mashrua wells for four hours by each well. Table 3, shows districts of water distribution system feeding wells in each area and the time table of water distribution in Winter season (December 2011, January and February 2012 cycle). It's clear from tables 2 and 3 that the hours of water supply from each well to Beit Lahya district varies between winter and summer seasons. For example, the Salateen district is supplied with water for 19 hours in summer and 13 hours in winter.

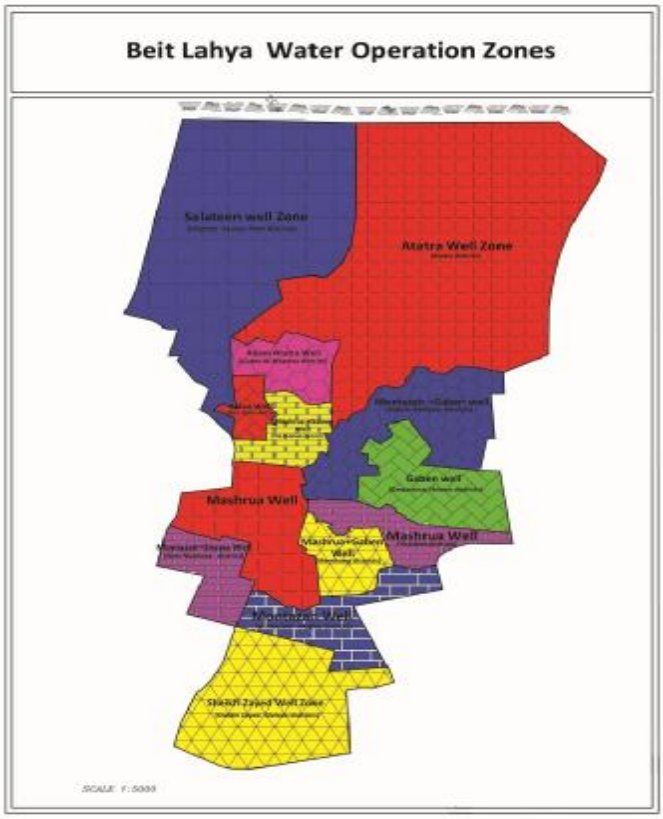

Figure 1. Water distribution zones in Beit Lahya

IV.III Quantities of Water Supply and Meter Readings

Water supply values reported in Tables 2 and 3 are results of Multiplying the number of pumping hours by the well hourly production rate. Then the total amounts of water pumped to the water distribution system during cycles are 1,141,500 m^3 in May and June cycle, 1,183,300 m^3 in July and august month cycle and reached 785500 in January and February 2012 cycle. It is clear that each person share of water that is pumped to the water network reached 270 m^3 per day , which is so high amount if compared to the Gaza strip average consumption of 100 l/cap/day , taking in consideration that the population of Beit Lahya is 72,500 people. As shown in Tables 3 and 4, the area that gets the highest rate of supply is the Salateen area. For example, Salateen area consumed 234000 and 150000 cubic meters of water in 2011 summer and winter seasons, respectively.

Table 1: Timetable of Water Distribution System for June and July August 2011

District	Water resources supply	Production (m^3/hour)	Pumping hours/ day	Pumping hours/ day	Pumping hours/ day
			June 2011	July 2011	August 2011
Salateen	Salateen well	200	19	19	20
Al Atatra	Atatra well	70	18	18	18
Al Guraa al khamsa	Aslan well	80	3.5	4	4
	Atatra well	70	3.5	4	4
Tal Eldahab	Gaben well	130	4	4	4
	Mashrua well	180	2	2	2
Abu Obida	Aslan well	80	3	3	3
Jamaea and Gaben	Montazah well	180	6	6	8
	Gaben well	130	7	6	7
Gawasma and Shimaa	Gaben well	130	5.5	5.5	5.5
AL Hatabea	Mashrua well	180	2.5	2.5	2.5
AL Manshaea	Gaben well	130	3.5	4	4
	Mashrua well	180	4	4	4
El Maslakh and Magles	Montazah well	180	6.5	6.5	8
Sheikh Zayed	Sheikh Zayed well	150	16	16	15
Old Mashrua – Khazan and block 8	Mashrua well	180	11	12	12.5
New Mashrua	Montazah well	180	4	3.5	3.5
	Shawa well	100	19	Only district	19

IV.IV Water Consumption in Beit Lahya Districts

After determining the numbers of water customers in each zone of water distribution system, the total water consumption per zone was calculated and reported in Tables 3 and 4. The Tables also show the efficiency of the water distribution and the percent of unaccounted for water in each zone.

Table 2: Time schedule of Water Distribution System for December 2011, January and February 2012 (winter season).

District	Water resources supply	Production (m^3/hour)	Pumping hour/ day	Pumping hour/ day	Pumping hour/ day
			December 2011	January 2012	February 2012
Salateen	Salateen well	200	13	13	12
Al Atatra	Atatra well	70	13	13	11
Al Guraa al khamsa	Aslan well	80	2	2	4
	Atatra well	70	2	2	2.5
Tal Eldahab	Gaben well	130	3.5	3.5	2
	Mashrua well	180	2	2	2
Abu Obida	Aslan well	80	2	2	2
Jamaea and Gaben	Montazah well	180	4	4	3
	Gaben well	130	5	5	3.5
Gawasma and Shimaa	Gaben well	130	4	4	4
AL Hatabea	Mashrua well	180	2	2	2
AL Manshaea	Gaben well	130	3	3	2.5
	Mashrua well	180	3	3	3
El Maslakh and Magles	Montazah well	180	5	5	4
Sheikh Zayed	Sheikh Zayed well	150	13	13	12
Old Mashrua – Khazan and block 8	Mashrua well	180	10	10	10
New Mashrua	Montazah well	180	3	3	3
	Shawa well	100	9	9	8

IV.V Water distribution system Efficiency

Using the supply and demand data enables the calculation of the efficiency of water distribution system of Beit Lahiya municipality through comparison between supplied water and consumed water. By analyzing the data presented in Tables 2 , 3 and 4 it was found that the overall efficiency of water network in beit Lahia is 44.3% in summer and 55.5% in winter. This means that the UFW is in the range of 44.5 to 55.7% with an average of 50.1%, which is very high if compared to the maximum rate in developing countries in Asia of 42%.

It is clear from Table 3 that the highest percentage of UFW in the network were in Salatin and Fardaus districts (mostly farm land) as the losses in this district is 72.5%. Areas of El Maslakh, Gamaea and Gaben, Al Atatra, Tal Eldahab , and Hatabea come next to Salateen and Fardaus areas in efficiency. These areas are characterized by their large areas of agricultural lands. The initial analysis shows that consumers in these districts uses municipality water to irrigate their lands. Through the table, it's clear that the least losses are shown for Old Mashrua , which has high percent of efficiency that reached 83.6% and has low UFW (16.4%).

Table 3: water network efficiency in July and August, 2011 (summer cycle)

District	Water resources supply	water consumption quantity (m3/July +August month)	water supply quantity (m3/ July +August month)	Eff %	UFW %
Salateen - Fardaus	Salateen well	64362	234000	27.5	72.5
Al Atatra	Atatra well	26972	75600	35.7	64.3
Al Guraa al khamsa	Aslan well	17800	36000	49.4	50.6
	Atatra well				
Tal Eldahab	Gaben well	19071	52800	36.1	63.9
	Mashrua well				
Abu Obida	Aslan well	7737	14400	53.7	46.3
Gamaea and Gaben	Montazah well	43206	126300	34.2	65.8
	Gaben well				
Gawasma and Shimaa	Gaben well	25015	42900	58.3	41.7
AL Hatabea	Mashrua well	11438	27000	42.4	57.6
AL Manshaea	Gaben well	35758	74400	48.1	51.9
	Mashrua well				
El Maslakh and Magles	Montazah well	23357	78300	29.8	70.2
Sheikh Zayed	Sheikh Zayed well	60000	139500	43.0	57.0
Old Mashrua – Khazan and block 8	Mashrua well	110662	132300	83.6	16.4
New Mashrua	Montazah well	78698	149800	52.5	47.5
	Shawa well				
total consumption		524076	1183300	44.3	55.7

It is known that Almashrou, block 8 and Alkhazzan districts are natural expansion of Jabalya refugee camp, whereas it is only residential areas without agricultural lands. These districts are selected in the study to compare the efficiency of water distribution system with semi urban districts to emphasize

the fact of using the water distribution network illegally for irrigation. Based on the field survey, most of the agricultural areas in Al-Atatara and Fardous are cultivated with strawberry, carnation and vegetables in green houses. In the Gaza Strip, irrigation practices are only based on the farmer's own experience. They determine when and how to irrigate crops based on the appearance of the soil and the climatic conditions. The irrigation practice exceeds the standard irrigation requirement by 30% leading to overexiplotation of groundwater and increasing the operational cost of water supply network (Al-Najar, 2011). Beit Lahya is still characterized by its rapid increase of population and expansion of urban areas. Large-scale, export-oriented agricultural production has reached its limits of land-use availability and, at the same time, is confronted with the socio-economic demands related to food insecurity and the need for income generation. Chemically intensive, unsustainable farming practices are leading to soil degradation, depletion and contamination of the vulnerable water resources. The concentration of chemical pollutants, including nitrate and chloride have exceeded the standards recommended by WHO (MOH, 2009, Al-Najar and Adeloye, 2005)

Table 4: water network efficiency in January and February 2012 (winter cycle)

District	Water resources supply	Meter readings (m^3/January +February 2012)	water supply quantity (m^3/January + February 2012)	Eff %	UFW %
Salateen-Fardaus	Salateen well	59300	150000	39.5	60.5
Al Atatra	Atatra well	26500	50400	52.6	47.4
Al Guraa al khamsa	Aslan well	14149	23850	59.3	40.7
	Atatra well				
Tal Eldahab	Gaben well	15119	43050	35.1	64.9
	Mashrua well				
Abu Obida	Aslan well	6100	9600	63.5	36.5
Jamaea and Gaben	Montazah well	40177	70950	56.6	43.4
	Gaben well				
Gawasma and Shimaa	Gaben well	19243	31200	61.7	38.3
AL Hatabea	Mashrua well	10129	21600	46.9	53.1

AL Manshaea	Gaben well	30150	53850	56.0	44.0
	Mashrua well				
El Maslakh and Magles	Montazah well	16448	48600	33.8	66.2
Sheikh Zayed	Sheikh Zayed well	50159	75000	66.9	33.1
Old Mashrua – Khazan and block 8	Mashrua well	83550	102,550	81.4	18.6
New Mashrua	Montazah well	62191	99400	62.6	37.4
	Shawa well				
total consumption		**433215**	**780100**	**55.5**	**44.5**

Increasing competition among urban needs makes soil and especially water very limited resource. “Agriculture in Gaza is already more urban than rural”, referring to the high degree of urbanization of the area (Al-Najar 2007). Urban agriculture is not a new or recent invention. However, only recently has urban agriculture become a systematic focus of research and development attention as its scale and importance in the urbanizing world become increasingly recognized (Van Veenhuizen, Prain & De Zeeuw 2001). A recent study by the United Nations Development Program (UNDP) indicated that about 800 million urban residents worldwide are involved in urban agricultural activities as a survival strategy. Between 1993 and 2005, urban agriculture could increase its share of world food production from 15% to 33% (Smit, 1996). A field survey has been conducted by the researcher, municipal staff in the department of meter reading and volunteers indicated that; urban agriculture influences the efficiency of water supply network due to the use of the domestic water networks illegally to irrigate the surrounding green houses. As shown in Tables 3 and 4, Salateen and Fardous regions in Beit Lahya show high unaccounted for water where the agricultural lands are proportionally higher than other districts. The field survey has been conducted to more than 650 customers in various districts of the municipality boundary. It focused on the agricultural land owned by the customer and the meter readings. The result of field survey is shown in Table 5.

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Table 5: Agricultural land in Beit Lahya districts by field survey

district	owned land	Residential land	Agricultural land	The proportion of agricultural land	Un accounted for water (UFW)
	km^2	km^2	km^2	%	%
Al Atatra	24580	10446	8657	35.2	62.4
Salateen	72157	23980	37360	51.8	73.4
Al Guraa al khamsa	5687	2000	1760	30.5	47.1
Old Mashrua – Khazan and block 8	13470	8220	1312	9.74	24.1
New Mashrua	7850	5240	1170	14.9	46.1
Jamaea and Gaben	37220	20131	6620	17.8	64.5
Gawasma and Shimaa	19680	7440	5642	28.7	45.3
AL Manshaea	10440	6123	1480	14.2	53.6
Sheikh Zayed	19080	7730	7750	40.6	66.1
El Maslakh and Magles	10980	6070	3230	29.4	73.3

By reference to the map uses of land to the Beit Lahiya city , it shows that agricultural land is concentrated in the following areas: Al Atatra, Salateen, Jamaea and Gaben, Gawasma and Shimaa and El Maslakh as show in Table 6.

Table 6: Agricultural land in Beit Lahya districts by land uses map

district	Agricultural land	UFW
	km^2	%
Al Atatra	2007.314	62.4
Salateen	1500	73.4
Al Guraa al khamsa	0	-
Old Mashrua – Khazan and block 8	0	-
New Mashrua	0	-
Jamaea and Gaben	466.136	64.5
Gawasma and Shimaa	51.406	45.3
AL Manshaea	0	-
Sheikh Zayed	226.302	66.1
El Maslakh and Magles	379.01	73.3

It was noticed Noted that the areas with high UFW are the same areas that have high percentage of agriculture land by field survey and land use map such as Al Atatra ,Salateen , Sheikh Zayed and El Maslakh and Magles zones.

V. CONCLUSION

The total amount of water pumped to the water distribution system during summer cycles is 1,141,500 m^3 (May and June), 1,183,300 m^3 in July and august months cycle and reached 785500 in January and February 2012 cycle. It is noticed that the amount of water that was pumped to the network has changed significantly between summer and winter seasons, which explain that the water lost is used in the irrigation of crops.

Old Mashrua has high percent of efficiency that reached 83.6% in summer season and 81.4% in winter season. This emphasis the idea that there is no agricultural areas in this district which is a natural extension of Jabalya refugee camp, that is characterized by high population and high population density. The zones that has high UFW such as Atatra , Salateen , Sheikh Zayed and El Maslakh and Magles zones are found to be the same zones that contain huge agricultural area according to the field survey and land use map.

References

1. Al-Najar H. (2011). "The integration of FAO-CropWat model and GIS techniques for estimating irrigation water requirement and its application in the Gaza Strip". Natural Resources. 2011, 2, 146- 154.
2. Al-Najar H. (2007). "Urban agriculture and Eco-sanitation: The strategic potential toward poverty alleviation in the Gaza Strip". RICS Research 7(7): 9-22.
3. Palestinian Ministry of Health (MOH), (2009). "The status of health in Palestine 2008", Annual report, periodical analysis for drinking wells, Palestinian Authority, Gaza Strip. p. 40-47.
4. Al-Najar H., A.J. Adeloye (2005). "The effect of urban expansion on groundwater as a renewable resource in the Gaza Strip". RICS Research 5(8): 7-21
5. Beit Lahya Municibility, (2011). "Anual Municibility report 2010". Gaza Strip, un puplished.
6. Environmental Protection Division (EPD), (2007). "water loss control program, guidance document". United State.
7. Palestinian Central Breuer of Statistics (PCBS), (2009). "Preliminary Results for the Census of Population and Inhabitants". Palestinian Central Beurou of Statistics, Ramallh.
8. Sharma, S. (2008). "Performance Indicators of Water Losses in Distribution System". M.Sc. thesis. Delft, The Netherlands.
9. Smit, J. (1996). "Urban Agriculture - Food, Jobs and Sustainable Cities". UNDP United Nations Development Program, New York
10. Van Veenhuizen, R. Prain, G. and De Zeewu, H. (2001). "Appropriate Methods: Research, Planning, Implementation and Evaluation for Urban Agriculture". Urban Agriculture Magazine. Vol. 1. No. 5.